



Plume Design, Inc
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Palo Alto, CA 94306

November 30, 2021

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Re: Plume Design, Inc. (“Plume”) Proposal to be Approved as an Automated Frequency Coordination System Operator (ET Docket No. 21-352)

Dear Ms. Dortch,

Attached please find Plume’s proposal to become an Automated Frequency Coordination system operator.

Should you have any questions or need additional information, please use the contact information provided in the proposal.

Respectfully submitted,

/s/ Shari Piré

Shari Piré
Chief Legal Officer

William McFarland
Chief Technology Officer

Prashant Jadhav
Principal Systems Engineer

**Plume Design, Inc. (“Plume”) Proposal for Approval as an
Automated Frequency Coordination System Operator**

ET Docket No. 21-352

In response to the Federal Communications Commission’s (“FCC’s” or “Commission’s”) *AFC Public Notice*,¹ Plume Design, Inc. (“Plume”) submits this proposal to be certified as an Automated Frequency Coordination (“AFC”) System operator. As described in more detail below, Plume’s AFC system will be based on open-source software. Specifically, it will utilize OpenSync² as well as the Open AFC Software designed by the Telecom Infra Project’s (“TIP’s”) Open AFC Software Project³ which is currently available to TIP members.

Plume’s experience and scope of current operations make it well-suited to serve as an AFC System operator. Plume is the creator of the world's first software-as-a-service (“SaaS”) experience platform for Communications Service Providers (“CSPs”) and their subscribers, which is deployed in more than 35 million locations globally. As the only open and hardware-independent, cloud-controlled consumer experiences platform, Plume enables the rapid delivery of new services at massive scale, including for smart homes and small businesses. On the front end, Plume delivers self-optimizing Wi-Fi, cyber-security, access and parental controls, and more. CSPs receive robust data- and AI-driven back-end applications for unprecedented visibility, insights, support, and operations.

Plume is particularly interested in operating an AFC System because it currently manages a large number of Wi-Fi networks in the United States. Plume does this both through its direct-to-consumer business, but also on behalf of CSPs that contract with Plume to manage their Wi-Fi networks as described above. Through its platform, Plume optimizes these networks to achieve the best performance possible. The Wi-Fi networks that Plume manages will add, over time, operations in the 6 GHz band. As a result, part of the optimization performed by Plume going forward will involve selecting the correct 6 GHz channel for operation considering the allowable transmit power each access point (“AP”) can utilize on each of the 6 GHz channels. This service will inherently involve activities similar to those performed by an AFC System operator.

¹ *The Commission Begins the Process for Authorizing 6 GHz Band Automated Frequency Coordination Systems*, Public Notice, FCC No. 21-200, ET Docket No. 21-352 (rel. Sept. 28, 2021).

² <https://www.opensync.io/>

³ <https://telecominfraproject.com/open-afc/>

Plume is dedicated to improving the Wi-Fi provided to the American people. By serving as a 6 GHz AFC system operator, Plume can leverage its expertise to enhance the Wi-Fi experience of its over 20 million customers in the United States, helping them achieve higher speeds and more robust connections to the Internet.

Responses to the specific requests for information set forth in the *AFC Public Notice* are provided below.

Question 1:

AFC system operator contact information, including name, phone number and email address that Commission staff may use for all AFC system related inquiries, such as information and data requests or to provide enforcement instructions.

Response to Question 1:

Legal contact:

- Shari Piré
Chief Legal and Sustainability Officer, Plume Design, Inc.
spire@plume.com
(917) 439-7883

Technical contacts:

- William McFarland
Chief Technology Officer, Plume Design, Inc.
bill@plume.com
(650) 823-6315
- Prashant Jadhav
Principal Systems Architect, Plume Design, Inc.
prashant@plume.com
(732) 306-0839

Question 2:

A technical diagram showing the architecture of the AFC system with a brief description of its operation.

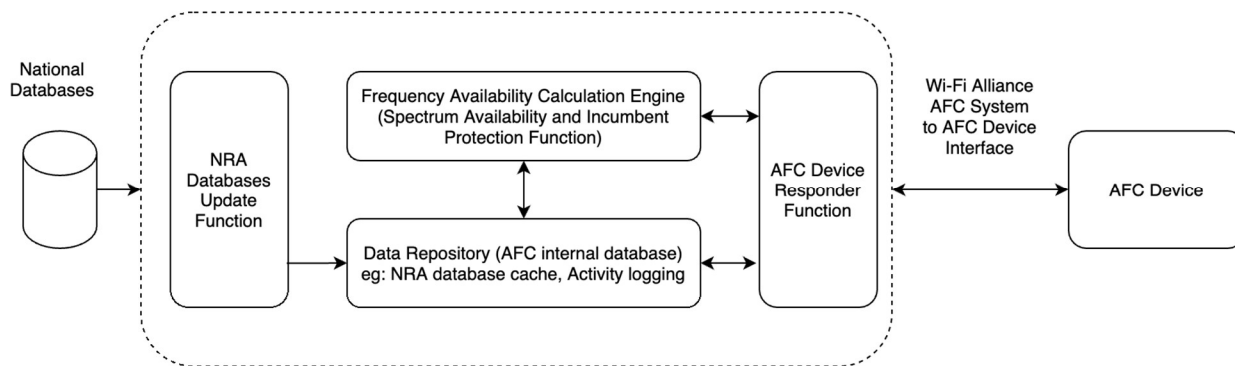
Response to Question 2:

Plume's AFC system will utilize the Open AFC System developed by the AFC working group at the Telecom Infra Project (TIP). The Open AFC System is open-source software that can be customized by AFC Operators to: (1) import and update data from FCC databases (e.g., the ULS database and the Equipment Authorization System); (2) acquire, register, and maintain information (e.g., serial number) from license-exempt AFC Devices; (3) validate the AFC Device by verifying the FCC ID and ensuring that the device is not on the AFC system's internal deny list, or a record of devices identified as unauthorized or prohibited by the FCC; (4) respond to queries from AFC Devices with a data transmission providing the maximum allowed powers at each frequency as set forth in FCC requirements; (5) provide a list of all permissible frequencies within the 6 GHz band to validated authorized AFC Devices; and (6) retain necessary information to allow an AFC Operator to carry out AFC functions, comply with the recordkeeping requirements of the FCC, respond to FCC requests, and implement FCC mandates.

An AFC Device querying the AFC System using the Open AFC Software provides geographic location information to the AFC System. It may only select from the permissible frequencies and transmit power levels identified by the AFC System at that geographic location. A Client Device operates under the control of an AFC Device and may operate only at the allowed power levels indicated by the AFC Device, with a maximum power level that is consistent with FCC regulations for Client Devices.

The diagram below comes directly from the TIP documents.

Technical diagram:



Data Repository Function: This function houses three core datasets: (1) a database of incumbent services; (2) a database of access points that are authorized/certified to operate as AFC Devices, including specific AP identifiers and FCC authorization/certification identifiers; and (3) a database of activity logs pertaining to frequency calculations and AFC Device activity to comply with FCC

recordkeeping regulations. Plume will use Open AFC Software to update and maintain databases (1) and (2) through its NRA Database Update Function.

NRA Database Update Function: This function imports data from the relevant FCC Database to determine if there are any changes to Incumbent Licensing Information, additions of information related to temporary fixed microwave links, changes to information related to border operations, and changes to the list of devices authorized/certified by the FCC to operate as AFC Devices. Plume's AFC System will use this function to populate, update, and maintain databases (1) and (2) in the Data Repository Function.

AFC System Frequency Availability Calculation Function: This function performs calculations to identify frequencies and power levels that are permissible for AFC Device operation at specific geographic locations. AFC Devices provide geolocation information through the AFC Device Responder Function. FCC Databases provide relevant Incumbent Licensing Information through the NRA Database Update Function.

AFC Device Responder Function: This function handles queries from AFC Devices and communicates either an error message to unauthorized or denied AFC Devices or a list of permissible frequencies and transmit power levels to validated AFC Devices. Plume's AFC System will use the AFC System Frequency Availability Calculation Function to populate responses to AFC Device queries.

Plume will use the specifications of the Wi-Fi Alliance AFC System to AFC Device Interface to define the information that is exchanged between the AFC Device and the AFC System. However, based on Plume's experience and system for managing large numbers of Wi-Fi APs, Plume may make changes to the protocols and data formats used for exchanging the information between the AFC Device and AFC System.

Question 3:

A description of whether the AFC system software is based on a proprietary implementation or open source.

Response to Question 3:

Plume's AFC system will be based on open-source software. The core functionality of Plume's AFC system will be based on the Open AFC System being designed, developed, and provided by TIP to its members. In addition, the data exchanged between the AFC Device and the AFC System will match that specified by the Wi-Fi Alliance in the AFC System to AFC Device Interface, which the Open AFC project will also make available as open source. Finally, Plume's Wi-Fi

management system makes use of a software agent that goes onto Wi-Fi APs called OpenSync. OpenSync is available as open source at [OpenSync.io](https://www.opensync.io)⁴ and is present on the APs that Plume currently manages and will manage in connection with the AFC system.

Question 4:

A demonstration that the prospective AFC system operator possesses sufficient technical expertise to operate an AFC system.

Response to Question 4:

Plume has experience in four areas that make it uniquely qualified to operate an AFC system:

- **Scale:** Plume's cloud based Wi-Fi management system is currently managing over 40 million APs worldwide. More than 23 million of those APs are in the United States. This is likely the largest number of APs being managed by any single entity in the United States.
- **Real-time, and nightly-scheduled management:** Plume's system is based on optimization to find the best configuration for a set of APs in a given home or workplace. These optimizations are performed on all locations that Plume is managing each night. In addition, when conditions warrant it, Plume can respond with a new optimization and configuration within minutes.
- **Wireless knowledge:** Plume is recognized as a leader in Wi-Fi management including radio propagation, spectrum regulatory matters, performance optimization, AP configuration, and Wi-Fi client control.
- **Experience managing spectrum:** Plume's systems already perform active frequency management. Plume's optimization system selects frequency channels for all the APs it manages, often across entire apartment complexes. It also manages client connections, guiding them to the correct AP and frequency band to maximize performance while conforming to regulatory limitations. In particular, Plume has developed deep expertise in Dynamic Frequency Selection (DFS) in the 5 GHz band. Plume's system in this area is extremely advanced, supporting coordinated DFS operation across multi-AP mesh networks, and applying learning techniques to help systems avoid operating on channels likely to be in conflict with 5 GHz radar systems. The Commission has certified many Plume-designed APs, including APs that utilize DFS in the 5 GHz band.

⁴ <https://www.opensync.io/>

The following table lists key members of Plume’s AFC development team.

Key Personnel	Role	Qualifications
William McFarland	Project Lead and Plume CTO	Active in the field of Wi-Fi since 1999. Participation in the standardization of 802.11g, 802.11h, 802.11n, 802.11ac. 35 technical publications, over 90 patents, elected Fellow of the IEEE in 2014 for work in Wi-Fi. M.S. Electrical Engineering from UC Berkeley.
Mani Balakrishnan	Wi-Fi Systems Lead	11 years’ experience in cloud-managed wireless systems. 19 published papers, 5 patents. Ph.D. Computer Engineering from New Mexico State.
Prashant Jadhav	Principal Architect	12 years’ experience in Wi-Fi, including hardware, software, and systems. Experience testing and filing for FCC certification for Wi-Fi devices. Participating in Wi-Fi Alliance AFC Task Group, and the TIP Open AFC Software Project. M.S. Electrical Engineering from the Rutgers University WINLAB.
Evan Jeng	Cloud Software Lead	8 years’ experience in software, including device software and cloud software. Architect of Plume’s cloud system that serves over 35 million homes in real time. M.S. Electrical Engineering from Stanford University.
Derek Lownsborough	Device Software Lead	24 years’ experience in embedded and system software. 3 patents. B.S. Computer Science from University of Victoria.

Moreover, due to the use of industry-developed standards and code, many industry experts outside of Plume will also be working to ensure that the solution is compliant with Commission requirements.

Question 5:

A description of the prospective AFC system operator's recordkeeping policies, including registration record retention as well as retention of historical frequency availability data.

Response to Question 5:

Plume's AFC system will retain AFC Device information and frequency availability data in a manner consistent with the Commission's rules, including 47 CFR § 15.407(k)(5) and (k)(15)(i). As mentioned in our response to Question 2 above, Plume's AFC system will make use of the Data Repository function in the Open AFC System implementation for recordkeeping in accordance with the Commission's rules. Any future changes will be made in a manner consistent with the technical requirements stipulated in 47 CFR § 15.407. Moreover, Plume's AFC system will include the data fields specified in the AFC System to AFC Device Interface Specification developed by the Wi-Fi Alliance.⁵ Such fields will include the device FCC ID, serial number, antenna information, location information (and uncertainty), frequency ranges, Effective Isotropic Radiated Power, and expiration date and time, and this information will be retained in accordance with the Commission's rules.

Plume has extensive experience with retaining large quantities of information. Plume has historically retained frequency-related information, which Plume accesses to assist in optimizing the Wi-Fi networks that Plume manages. Plume also retains the results of each optimization for each location, including the frequencies assigned to each AP in connection with such optimization. In addition, Plume retains measurements of interference and radar detection.

Question 6:

A description of how the prospective AFC system operator will handle unanticipated situations that may disrupt performance of the system's required functions—ranging from exceptional cases that affect the system's ability to perform its required functions in isolated instances to cases involving the type of widespread disruption that an event like a system failure might cause.

Response to Question 6:

Plume has ample experience developing resilient systems and establishing processes for responding to and mitigating different types of service disruptions. Plume's current Wi-Fi management system has proven extremely reliable, achieving over 99.96% uptime. It has been adopted by and is relied upon by more than 260 CSPs worldwide. Certain of the United States'

⁵ https://www.wi-fi.org/downloads-registered-guest/AFC_Specifications_and_Test_Plans.zip/38132

largest CSPs (and their respective subscribers) rely on Plume's current Wi-Fi management system. The Plume system is designed with features such as load balancing and auto-scaling to provide reliability and resiliency at scale. Plume will apply all of these techniques to its AFC system. Currently, the Plume system receives measurements from each AP once per minute, and examines such measurements in real-time, potentially reacting with a full optimization. By comparison to the Plume system, the requirements of an AFC system are modest.

All of Plume's systems are built with redundancy and appropriate independent behavior when connection to our clouds is not possible. Presently, Plume's system includes a variety of cross-checks and watchdog timers to detect any issues. In addition, Plume has the ability to readily update software both in the cloud and in the APs at any time. Plume's AFC system will include the same redundancy and safeguards to address any unanticipated situations to ensure uptime without interrupted performance.

Plume uses Amazon Web Services (AWS) to host the Plume cloud platform, which will include Plume's AFC system. The AWS system inherently brings data centers with all of the following robust properties:

- Redundant power systems
- Reliable environmental controls
- Multi-site operation with immediately failover
- Data backup
- Denial of service protection

Question 7:

A description of the methods (e.g., interfaces, protocols) that will be used for secure communication between the AFC system and its associated standard-power devices.

Response to Question 7:

General

Plume has been managing networks for six years without any significant security incidents. From inception, our systems were designed and built to prioritize security, and Plume's AFC system will be no different. Plume will use modern, robust and secure protocols and processes to protect the security of the AFC system and communications between the AFC System and its associated standard-power devices.

Physical Security

All Plume cloud systems run using the AWS service. Amazon utilizes a robust set of physical security measures. Plume will continue to use the AWS-cloud hosted services for the Plume AFC system.

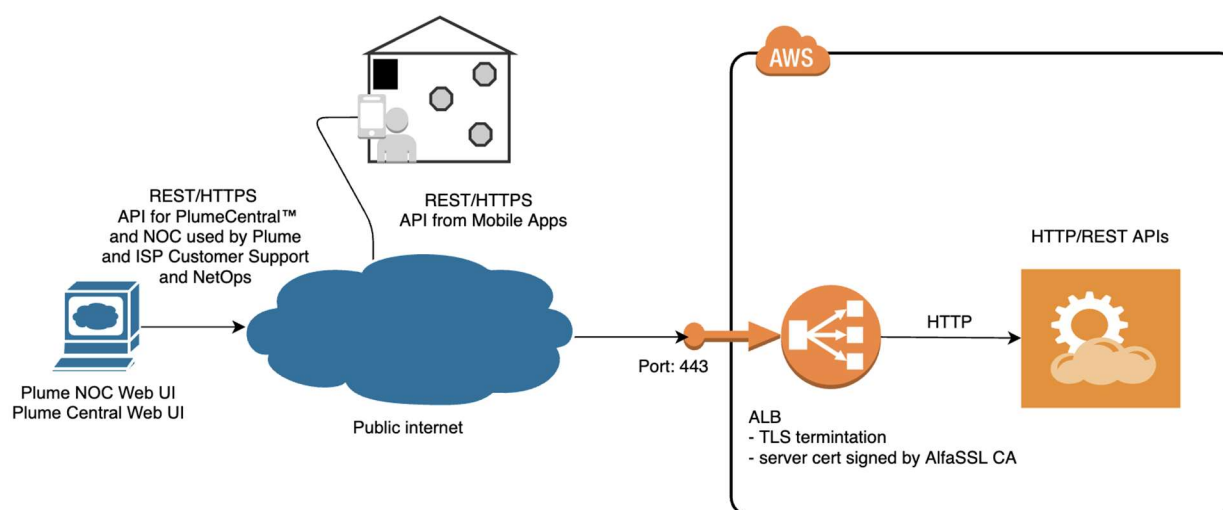
Authentication and Access Controls

The Plume system uses a state-of-the-art single sign on (SSO) system for managing access to all of Plume's systems. This allows Plume to provide access to users on an individual basis for each separate element of the Plume cloud. The SSO also keeps logs which provide a traceable record. Moreover, Plume has a policy of minimizing the number of users that can access any portion of any Plume cloud. Plume will implement all of these safeguards in its AFC system.

Data Security in Transit

Currently all communications between the Plume cloud system and its associated APs are encrypted using transport layer security (TLS) 1.2. The Plume AFC system in the cloud and the associated devices will adopt the same security architecture. The TLS 1.2 secure communication is terminated at entry points in the Plume AWS virtual private cloud as reflected in the diagram below.

The Plume security system makes use of security certificates within the APs that are provisioned to connect to the applicable Plume cloud. APs that do not have a valid certificate are blocked, and prevented from connecting. Inbound communications encrypted with TLS are terminated at the AWS Application Load Balancer (ALB) or at the HAProxy.⁶ The HAProxy validates that each incoming TLS certificate is valid and signed by the Plume certificate authority.



⁶ <https://github.com/haproxy/haproxy/>

Software Security

The Plume system incorporates tools that enable Plume to ensure that no unauthorized software can be added onto the access points that Plume manages. Each firmware image is signed, and the signature is verified for all new software that is added onto any Plume access point. Plume's software, whether in the cloud or in the access point, is put through penetration testing as part of Plume's quality assurance process. Plume will use these same tools in its AFC system.

Question 8:

If the prospective AFC system operator will not be performing all AFC functions, information on (1) the entities that will be responsible for operating other functions of the AFC system; and (2) how the Commission can ensure that all of the requirements for AFC systems in the rules are satisfied when AFC functions are divided among multiple entities.

Response to Question 8:

Plume will provide a complete AFC system. This system will include all elements required in the cloud and all functions required in the access points. Plume does not anticipate relying on an external entity for the operation of any part of its AFC system, except for the use of the AWS cloud platform, operating as a generic compute platform. Please see our response to question 6 for additional details.

Question 9:

A description of how the prospective AFC system operator will provide access to their AFC system for a public trial period which will include thorough testing.

Response to Question 9:

Plume will make its AFC system available for testing during the public trial period. Users interested in testing the Plume AFC system will be able to contact Plume before or during the test period to receive instructions on how to connect to the system. Consistent with the Commission's 6 GHz Order, Plume will facilitate both lab testing in a controlled environment and field testing of its AFC system.

Plume has been providing trial (i.e., test) access to potential customers for its Wi-Fi management system for more than six years. So while Plume is still developing the details of how users will connect to the Plume AFC system during the testing period, Plume has a variety of tools at its

disposal to facilitate trial access to the public, including a separate cloud with special certificates specifically designed to provide customers with trial access.

Question 10:

An affirmation that the prospective AFC system operator, and any entities responsible for operating other functions of the AFC system under the control of the AFC system operator, will comply with all of the applicable rules as well as applicable enforcement mechanisms and procedures

Response to Question 10:

Plume affirms that it will comply with all of the applicable rules regarding AFC system operation, as well as applicable enforcement mechanisms and procedures.

Among other things, Plume affirms that its AFC system will: (1) be capable of determining the available frequencies in steps no greater than 3 dB below the maximum permissible EIRP of 36 dBm, and down to at least a minimum level of 21 dBm; (2) obtain information on protected services within the 5.925-6.425 GHz and 6.525-6.875 GHz bands from FCC databases and use that information to determine frequency availability for standard power access points and fixed client devices based on the protection criteria specified in the FCC's rules; (3) use the information supplied by standard power access points and fixed client devices during registration to determine available frequencies and the maximum permissible power in each frequency range for a standard power access point at any given location and to make all such determinations and assignments in a non-discriminatory manner; (4) store registered information in a secure database until a standard power access point or fixed client device ceases operation at a location (i.e., that device has not contacted its system for more than three months to verify frequency availability information); (5) verify the validity of the FCC identifier of any standard power access point and fixed client device seeking access to its services prior to authorizing the access point to begin operation; (6) obtain a list of standard power access points with valid FCC IDs from the FCC's Equipment Authorization System; (7) ensure that all communications and interactions between the AFC system and standard power access points and fixed client devices are accurate and secure and that unauthorized parties cannot access or alter the database, or the list of available frequencies or associated powers sent to a standard power access point; (8) implement the terms of the United States' international agreements with Mexico and Canada; (9) maintain a regularly updated AFC system database that contains incumbents' information and standard power access points and fixed client devices registration parameters; (10) provide service for a five-year term; (11) establish location and frequency-based exclusion zones (both co-channel and adjacent channel) around fixed microwave receivers operating in the 5.925-6.425 GHz and 6.525-6.875 GHz bands; (12) use the propagation models set forth in 47 CFR § 15.407(l)(1) to determine the appropriate separation distance between

a standard power access point or a fixed client device and an incumbent fixed microwave service receiver; (13) use the interference protection criteria for determining the size of the co-channel exclusion zone and the adjacent-channel exclusion zone set forth in 47 CFR § 15.407(l)(2); and (14) enforce the exclusion zones for radio astronomy services set forth in 47 CFR § 15.407(m).

Plume also affirms that: (1) it will respond in a timely manner to verify, correct, or remove, as appropriate, data that the Commission requires to be stored in its AFC system if the Commission or a party presents to Plume a claim of inaccuracies in the system; (2) establish and follow protocols to comply with enforcement instructions from the Commission, including discontinuance of standard power access point operations in designated geographic areas; and (3) provide at least 30-days' notice to the FCC and transfer any registration data to another AFC system operator in the event that Plume's AFC system ceases operation.